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PICKERING NGS 'A'
PRESSURE RELIEF DUCT
CONDITION SURVEY OF EXTERIOR CONCRETE

Report No 88-295-K

E.J. McColm
Engineer
Concrete Technology Section
Civil Research Department

ABSTRACT

A condition survey of the exterior concrete of the Pickering NGS 'A' pressure relief duct was conducted in September/October 1988. In general, the surface of the concrete appears to be in good condition. Localized cracking and spalling was observed along the lower portion of the sides and bottom of the duct. Because a majority of the inspection was carried out with the aid of binoculars, crack widths and depths could not be measured or estimated.

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TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
2.0	OBSERVATIONS	1
2.1	Top Surface	1
2.2	Bottom Surface	2
2.3	North Elevation	3
2.4	South Elevation	3
2.5	Bearing Pads	4
3.0	CONCLUSIONS AND RECOMMENDATIONS	4
APPENDIX A	- Top Surface - Test Results and Location of Cracks	6
APPENDIX B	- Bottom Surface - Location of Cracks	16
APPENDIX C	- North Elevation - Location of Cracks	22
APPENDIX D	- South Elevation - Location of Cracks	28
DISTRIBUTION		last page

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To: Mr. J. Kenthol
Manager
Civil Design Department

Attn: Mr. Z.M. Beg

PICKERING NGS 'A'
PRESSURE RELIEF DUCT
CONDITION SURVEY OF EXTERIOR CONCRETE

1.0 INTRODUCTION

In September/October 1988, a condition survey of the exterior concrete of the pressure relief duct (PRD) at Pickering NGS 'A' was carried out at the request of the Civil Design Department. The survey included a detailed inspection of the top surface of the PRD, consisting of crack mapping, impact hammer readings, and examination of the joint sealant material.

Access to the bottom surface, the north and south elevations and the bearing pads was not provided; therefore, these areas were only visually inspected with the aid of binoculars.

The results of the condition survey are summarized in this report.

2.0 OBSERVATIONS

For the purpose of the survey, the PRD was subdivided into sections bounded by the various joints (Joints 0 to 28, starting from east to west). The observations and test results are presented relative to the joint numbers.

2.1 Top Surface

The results of the inspection of the top surface of the PRD are given in Appendix A. The cracks in the top surface were mapped and the widths measured. Special attention was given to the areas along the joints, around the embedded parts including anchor bolts, and along the edges of the duct. In general, because of the weathered concrete surface and narrow widths

(<0.1 mm), it was difficult to detect the cracks (Figures A1 and A2). Only two cracks wider than 0.1 mm were identified, between Joints 5 and 6 and Joints 7 and 8 (width <0.5 mm), and these were located near the edges of the duct.

Numerous popouts and spalls are present on the top surface. Some of these have been repaired; however, new ones are developing. The popouts are primarily caused by particles of poor quality aggregate near the surface of the concrete. The spalls appear to be caused by both the aggregate (Figure A3) and as a result of mechanical damage such as impact forces. No reinforcing steel was observed exposed as a result of these popouts and spalls.

Concrete pads have been installed on the duct to support steel beams for piping. These pads are cast around anchor bolts embedded in the PRD. Around many of the pads, particularly on the south side of the duct, the concrete has spalled. The pads themselves are also spalled and cracked (Figure A4), exposing the reinforcement in some.

At two locations, between Joints 1 and 3, reinforcing steel is exposed at the surface of the slab. This situation appears to be construction related and has probably existed since the duct was built.

Impact hammer readings were taken along the top of the duct to compare the relative quality of the concrete and to provide reference values for future inspections. The readings were taken at the northeast, southeast, southwest and northwest corners, adjacent to each joint and within 2 m of the edge of the duct. The results, reported in Table A1, are all in the range associated with good quality concrete.

Using a Pundit (ultrasonic pulse velocity instrument), an attempt was made to evaluate the quality of the concrete by placing the transducers on either side of the duct and taking readings through the top slab. This was not successful because the span was greater than the range of the instrument. When measurements across shorter path lengths were attempted, erroneous readings were obtained, which were probably caused by the interference of reinforcing steel in the slab.

The sealant at the joints was visually inspected and durometer hardness readings taken. The results are reported in Table A2. Most of the joint sealant appears to be in good condition with no significant cracking or debonding. The exceptions are Joints 2 and 12 (Figure A5) where the sealant contains minor cracks and is significantly softer than that at the other joints. The significance of these readings should be reviewed by others.

2.2 Bottom Surface

The bottom surface of the duct was inspected with binoculars from a Condor man-lift and from permanent elevated walkways. The results of the inspection, showing the location of cracks and other forms of deterioration, are given in Appendix B (Figure B1).

The cracks in the concrete generally extend from the edge of the duct, with most being less than 1 metre long (Figures B2 and B3). The extent of cracking varies from section to section. Around some of the cracks, staining and efflorescence was observed. The width and depth of the cracks could not be measured or estimated because of the method of inspection. In addition, localized areas of map cracking were observed (Figure B4).

Minor spalling has occurred at some of the joints and around the embedded parts. Repairs have been made to the concrete adjacent to the pipes extending from the bottom of the duct. Some of the beams supporting the duct have also been repaired (Figure B5).

At several locations reinforcing steel is exposed at the surface of the concrete, apparently since construction.

2.3 North Elevation

The north elevation was visually inspected with binoculars from the roof of the powerhouse. Most areas could be viewed from this location, except areas adjacent to the reactor buildings where associated structures obstructed the view. Appendix C (Figure C1) gives the location of cracks and deterioration.

The cracks are generally located along the lower edge of the duct, the vertical joints, and the horizontal construction joint located approximately 1.5 m above the bottom of the duct (Figure C2). Staining and efflorescence is present around some of the cracks (Figure C3). The method of viewing the duct prevented measuring or estimating the crack widths and depths. It was also impossible to identify cracks with widths as small as those observed on the top surface of the duct.

Spalling of the concrete was noted at the lower portion of the duct at Joint 10 (Figure C4 and C5).

2.4 South Elevation

The south elevation of the duct was visually inspected with binoculars from the ground, and localized areas were viewed from the Condor man-lift. Between Joints 4 and 6, access was restricted by the Vacuum Building. The results of the inspection are given in Appendix D (Figure D1).

The cracking, as observed on the north elevation, is generally along the bottom edge of the duct, the vertical joints, and the horizontal construction joint located approximately 1.5 m above the bottom of the duct (Figure D2). Staining and efflorescence of the concrete is present at some of the cracks and joints (Figure D3). The method of viewing the duct prevented the crack widths and depths from being determined and small cracks from being identified.

2.5 Bearing Pads

The PRD is supported on five piers and four frames. At the expansion joints, the duct is supported on bearing pads. The bearing pads and contact between the support beams and the duct were visually inspected from the Condor man-lift, the top of the duct, and the roof of the powerhouse. Because of restricted access from these locations, a detailed inspection could not be conducted.

The bearing pads appear to be in good condition with only minor cracks extending from the embedded steel plates. Spalling was observed at Joint 10 above the bearing pad as mentioned in Section 2.3, North Elevation.

3.0 CONCLUSIONS AND RECOMMENDATIONS

1. The concrete generally appears to be in good condition with only minor deterioration. Cracks are concentrated near the lower portion of the duct at the edges and along the horizontal construction joints on either side. Minor popouts and spalls are present in the top surface, and at a few locations on the sides and bottom, the concrete has spalled.

2. Because of the method of inspection for the sides and bottom of the duct, the crack widths and depths could not be measured or estimated.

3. The significance of the spalling near Joint 10 at the bearing pad should be assessed by Civil Design.

4. The significance of the durometer hardness readings taken on the joint sealant should be assessed, particularly for Joints 2 and 12.

Approved by:

T.W. Klym
Manager
Civil Research Department

Prepared by:

E.J. McColm
Engineer
Concrete Technology Section

Reviewed by:

G.S. Kellay
Supervising Engineer
Concrete Technology Section

EJM:dmc

APPENDIX A

PICKERING NGS 'A'
PRESSURE RELIEF DUCT
TOP SURFACE - TEST RESULTS AND LOCATION OF CRACKS

TABLE A1
PICKERING NGS 'A' - PRESSURE RELIEF DUCT
TOP SURFACE - IMPACT HAMMER READINGS

LOCATION	NORTHEAST CORNER *I.H. Number	NORTHEAST CORNER **Estimated Strength MPa	SOUTHEAST CORNER *I.H. Number	SOUTHEAST CORNER **Estimated Strength MPa	SOUTHWEST CORNER *I.H. Number	SOUTHWEST CORNER **Estimated Strength MPa	NORTHWEST CORNER *I.H. Number	NORTHWEST CORNER **Estimated Strength MPa
Joint 0 to 1	47	50	46	48	45	46	44	45
Joint 1 to 2	44	45	46	48	45	46	46	48
Joint 2 to 3	46	48	47	50	46	48	49	52
Joint 3 to 4	45	46	45	46	44	45	45	46
Joint 4 to 5	47	50	44	45	44	45	49	52
Joint 5 to 6	48	51	44	45	43	43	46	48
Joint 6 to 7	45	46	45	46	44	45	45	46
Joint 7 to 8	47	50	46	48	48	51	48	51
Joint 8 to 9	43	43	45	46	44	45	42	41
Joint 9 to 10	44	45	45	46	46	48	47	50
Joint 10 to 11	44	45	41	40	45	46	44	45
Joint 11 to 12	42	41	41	40	42	41	43	43
Joint 12 to 13	45	46	43	43	44	45	47	50
Joint 13 to 14	41	40	46	48	48	51	43	43
Joint 14 to 15	43	43	45	46	46	48	48	51

* Impact Hammer numbers were obtained using a Schmidt Impact Hammer. Each number is the average of 10 readings

** The Estimated Strength is an approximate value only and represents differences in the quality of the surface concrete.

(CV11)

TABLE A1, Continued
PICKERING NGS 'A' - PRESSURE RELIEF DUCT
TOP SURFACE - IMPACT HAMMER READINGS

LOCATION	NORTHEAST CORNER *I.H. Number	NORTHEAST CORNER **Estimated Strength MPa	SOUTHEAST CORNER *I.H. Number	SOUTHEAST CORNER **Estimated Strength MPa	SOUTHWEST CORNER *I.H. Number	SOUTHWEST CORNER **Estimated Strength MPa	NORTHWEST CORNER *I.H. Number	NORTHWEST CORNER **Estimated Strength MPa
Joint 15 to 16	48	51	48	51	45	46	47	50
Joint 16 to 17	46	48	49	52	49	52	47	50
Joint 17 to 18	44	45	47	50	46	48	48	51
Joint 18 to 19	45	46	45	46	48	51	47	50
Joint 19 to 20	45	46	46	48	44	45	47	50
Joint 20 to 21	46	48	40	39	42	41	44	45
Joint 21 to 22	46	48	47	50	43	43	44	45
Joint 22 to 23	45	46	41	40	46	48	43	43
Joint 23 to 24	47	50	45	46	44	45	45	46
Joint 24 to 25	40	39	39	37	43	43	39	37
Joint 25 to 26	42	41	42	41	45	46	47	50
Joint 26 to 27	41	40	42	41	44	45	43	43
Joint 27 to 28	43	43	46	48	41	40	44	45
Joint 28 to end of duct	43	43	48	51	-	-	-	-

* Impact Hammer numbers were obtained using a Schmidt Impact Hammer. Each number is the average of 10 readings

** The Estimated Strength is an approximate value only and represents differences in the quality of the surface concrete.

(CV11)

TABLE A2

PICKERING NGS 'A' - PRESSURE RELIEF DUCT

TOP SURFACE - CONDITION OF JOINT SEALANT

JOINT NUMBER	DUROMETER HARDNESS South	North	REMARKS
Joint 0	37	39	- Expansion joint - Four patches on top surface of joint
Joint 1	49	47	- Construction joint
Joint 2	25	27	- Construction joint - Sealant is soft and cracked
Joint 3	49	50	- Construction joint - Minor debonding along edge
Joint 4	49	50	- Construction joint
Joint 5	37	40	- Expansion joint - Four patches on top surface of joint
Joint 6	55	48	- Construction joint
Joint 7	52	52	- Construction joint
Joint 8	54	58	- Construction joint
Joint 9	45	46	- Construction joint
Joint 10	46	44	- Expansion Joint
Joint 11	33	33	- Construction joint - One crack at right angles to joint
Joint 12	35	32	- Construction joint - Joint material is soft and cracked - See Figure A5
Joint 13	47	48	- Construction joint
Joint 14	42	42	- Expansion joint - Four patches on top surface of joint

(CV11)

TABLE A2, Continued

PICKERING NGS 'A' - PRESSURE RELIEF DUCT

TOP SURFACE - CONDITION OF JOINT SEALANT

JOINT NUMBER	DUROMETER HARDNESS South	North	REMARKS
Joint 15	44	47	- Construction joint
Joint 16	51	51	- Construction joint
Joint 17	52	51	- Construction Joint
Joint 18	40	41	- Expansion joint - Two patches on top surface of joint
Joint 19	51	48	- Construction joint
Joint 20	43	47	- Construction joint
Joint 21	47	55	- Construction joint
Joint 22	49	49	- Construction joint
Joint 23	41	41	- Expansion joint
Joint 24	45	45	- Construction joint
Joint 25	47	47	- Construction joint - A few minor cracks in sealant
Joint 26	45	51	- Construction joint - One minor crack in sealant
Joint 27	46	48	- Construction joint
Joint 28	43	43	- Construction joint

(CV11)

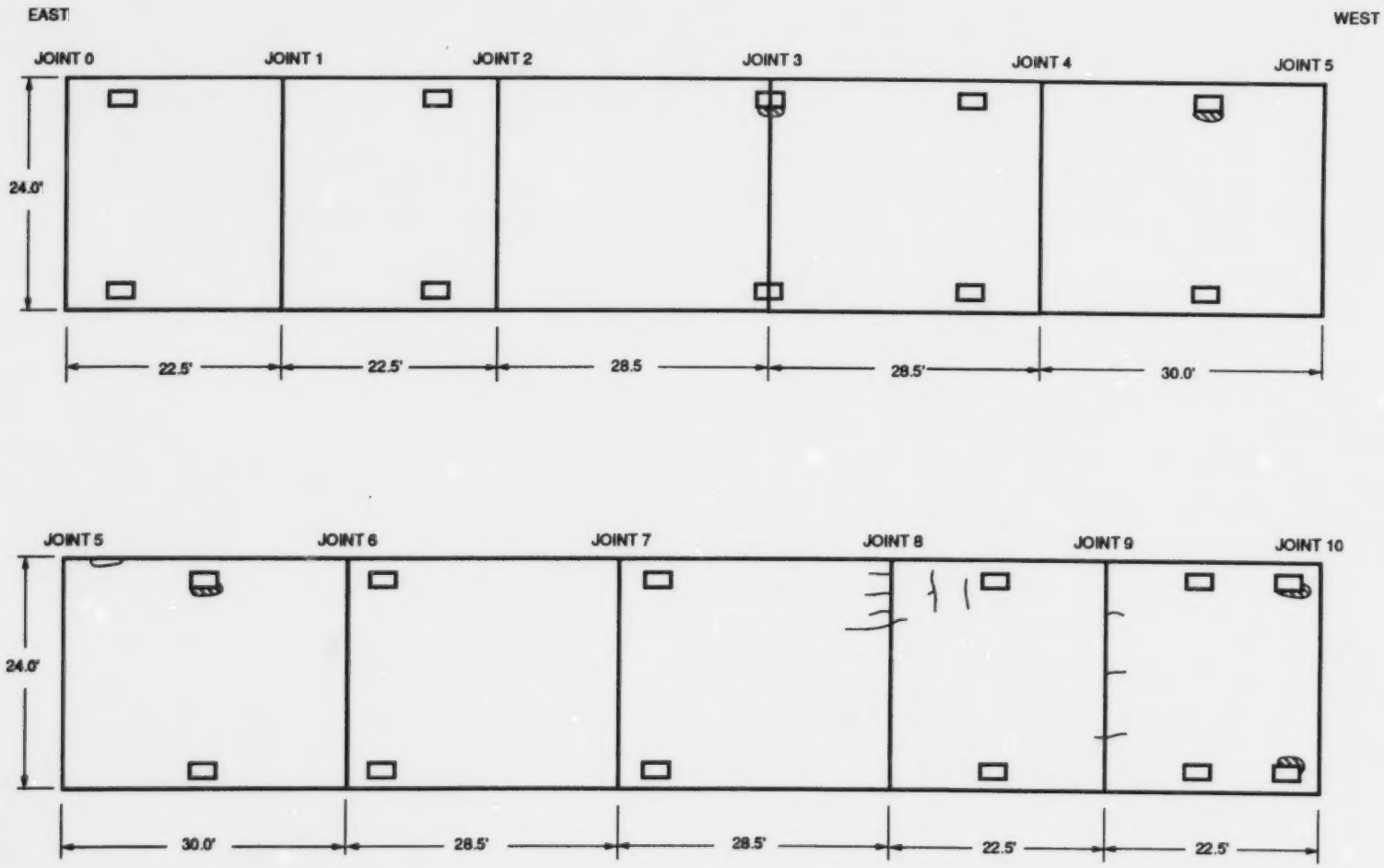


FIGURE A1

PICKERING NGS 'A'
PRESSURE RELIEF DUCT - EXTERIOR CONCRETE
TOP SURFACE

88-295
1786-6RD
VA 10 DISK

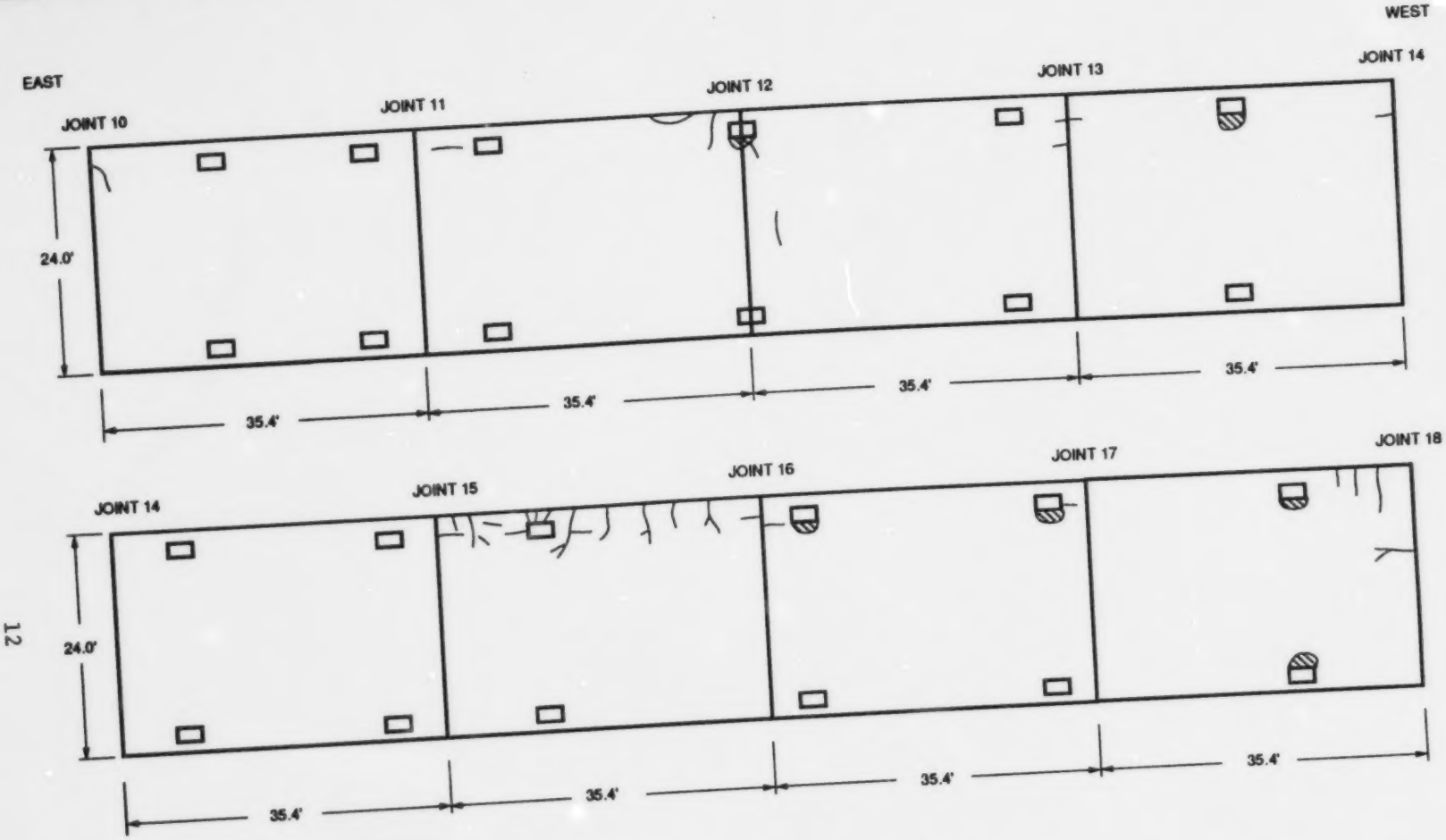


FIGURE A1 CONT'D
PICKERING NGS 'A'
PRESSURE RELIEF DUCT - EXTERIOR CONCRETE
TOP SURFACE

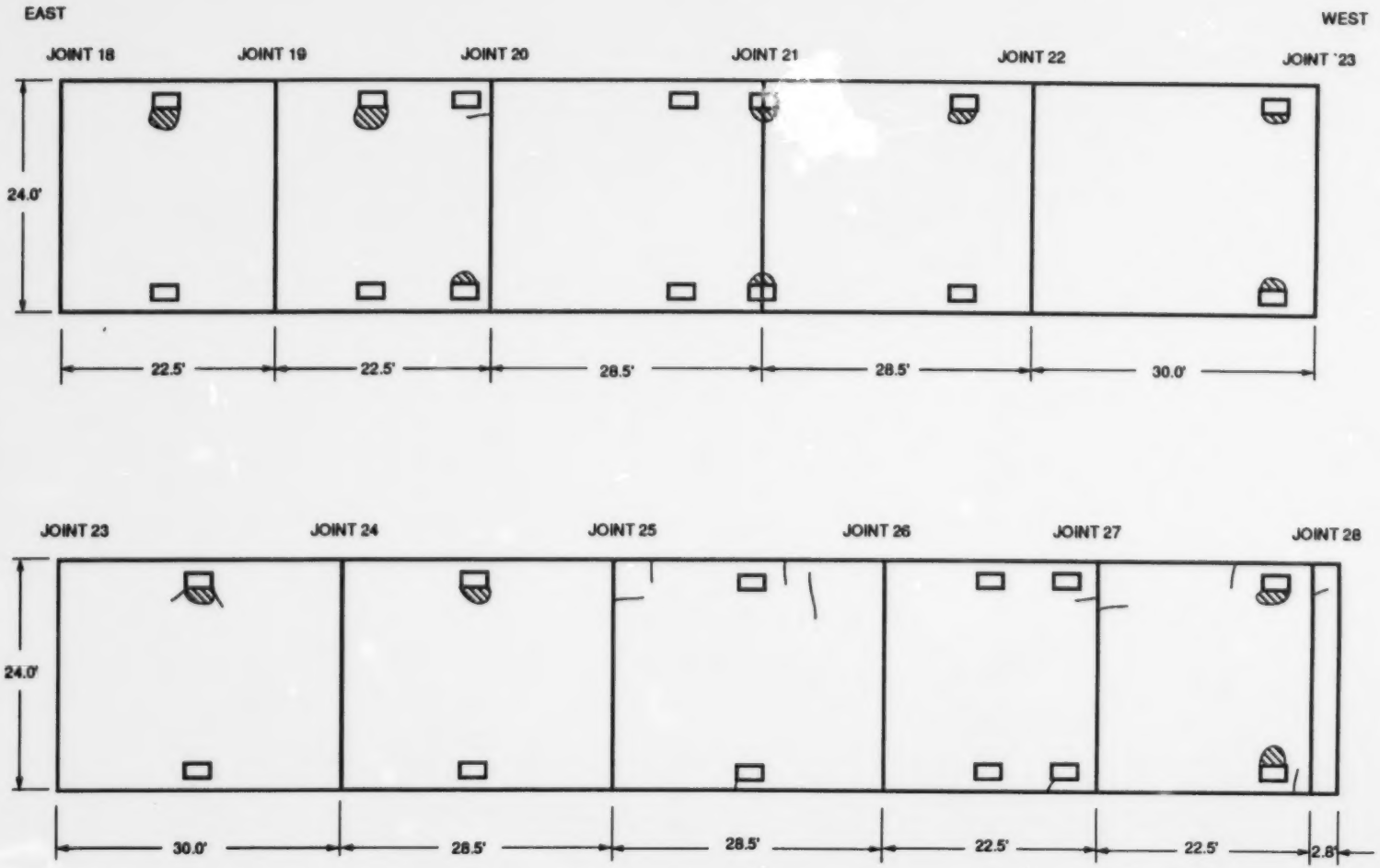


FIGURE A1 CONT'D
PICKERING NGS 'A'
PRESSURE RELIEF DUCT - EXTERIOR CONCRETE
TOP SURFACE

88-295
179831-RD
JA 10 DISK

Figure A2 - Typical hairline cracks present in the top surface of the PRD (width <0.1 mm).

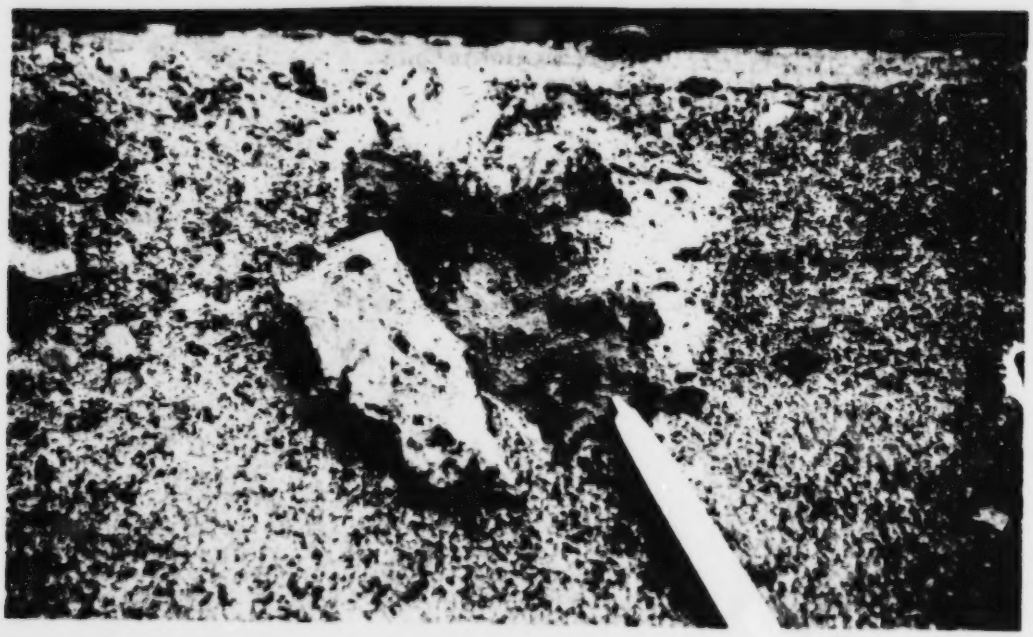


Figure A3 - Spall caused by poor quality aggregate close to the surface of the concrete.

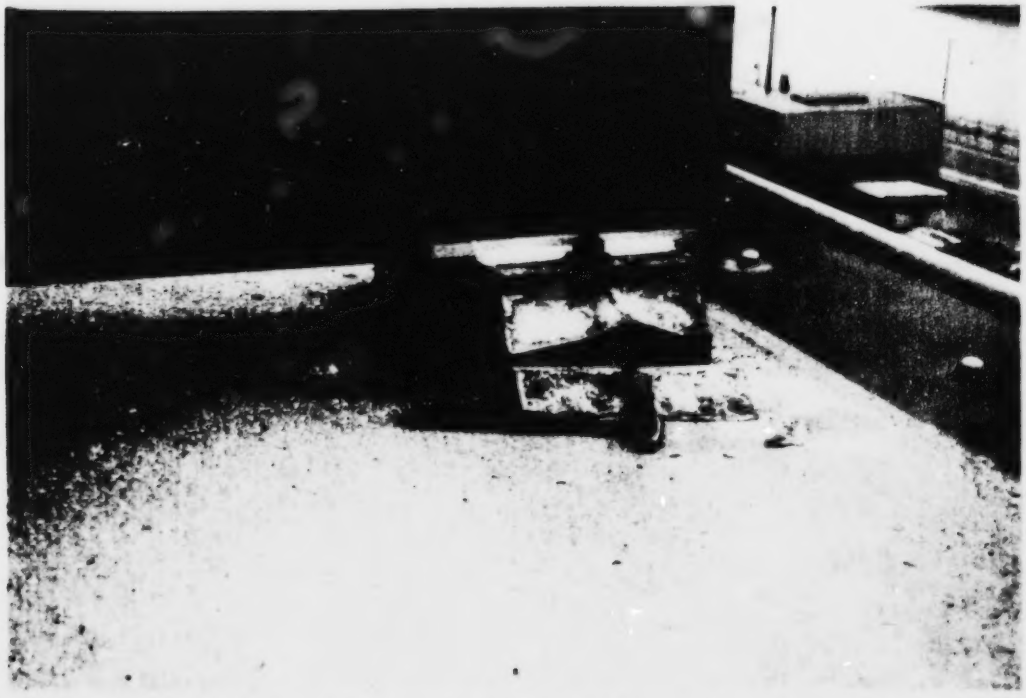


Figure A4 - Deterioration of a concrete pad and associated spalling of the concrete around the base of the pad. Many of the pads are deteriorated, particularly those on the south side of the duct.

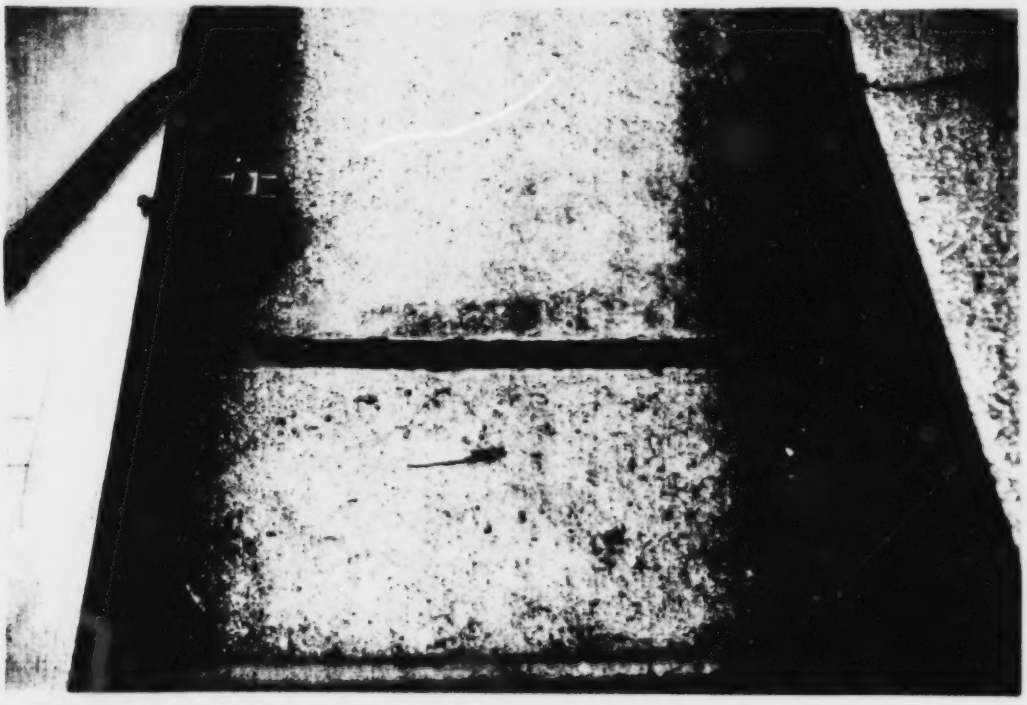


Figure A5 - Cracks in the sealant of Joint 12. This sealant is also softer than that of the other joints.

APPENDIX B

PICKERING NGS 'A'
PRESSURE RELIEF DUCT
BOTTOM SURFACE - LOCATION OF CRACKS

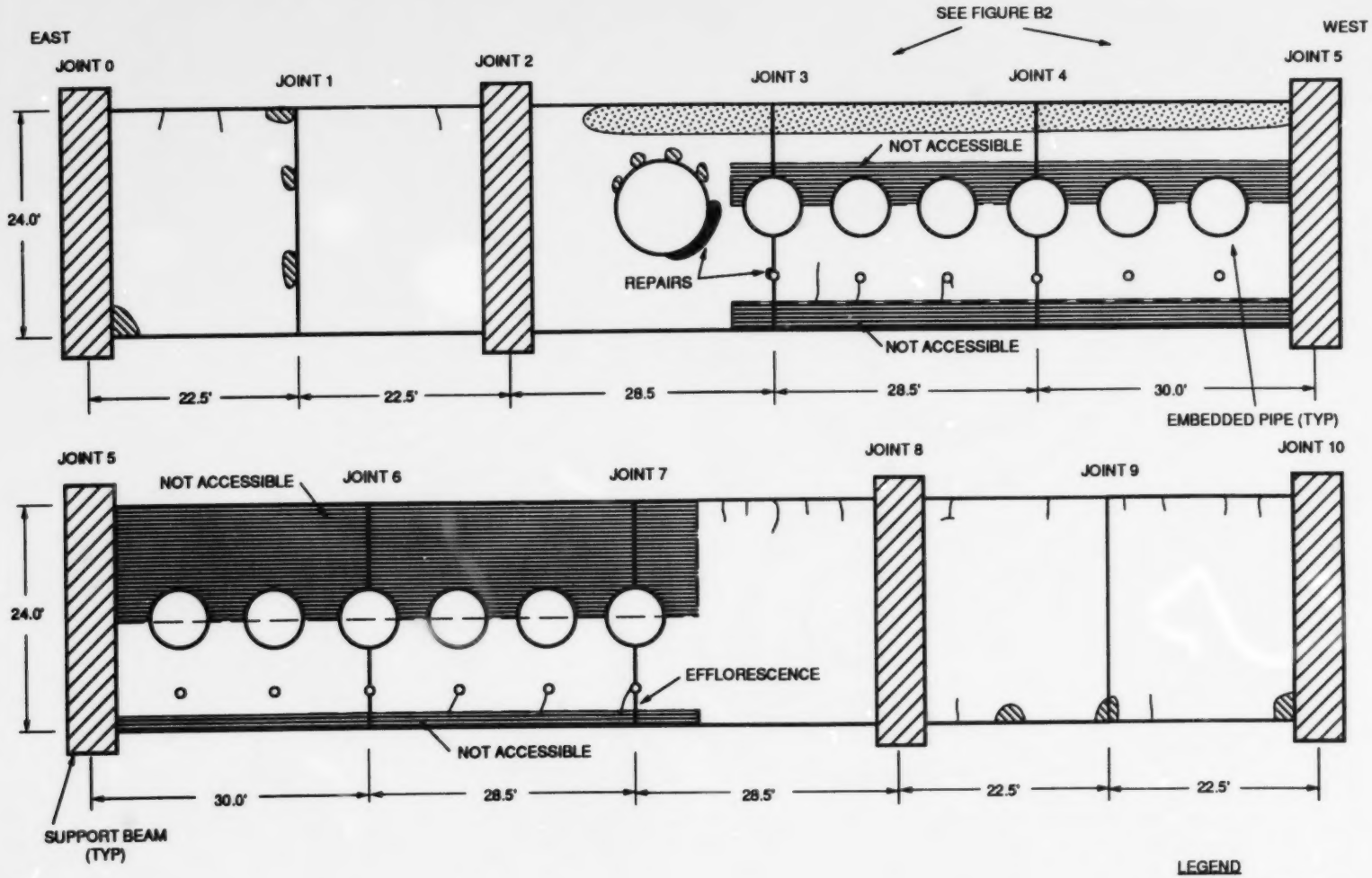


FIGURE B1
PICKERING NGS 'A'
PRESSURE RELIEF DUCT - EXTERIOR CONCRETE
BOTTOM SURFACE

178632-RD
JA 10 DISK

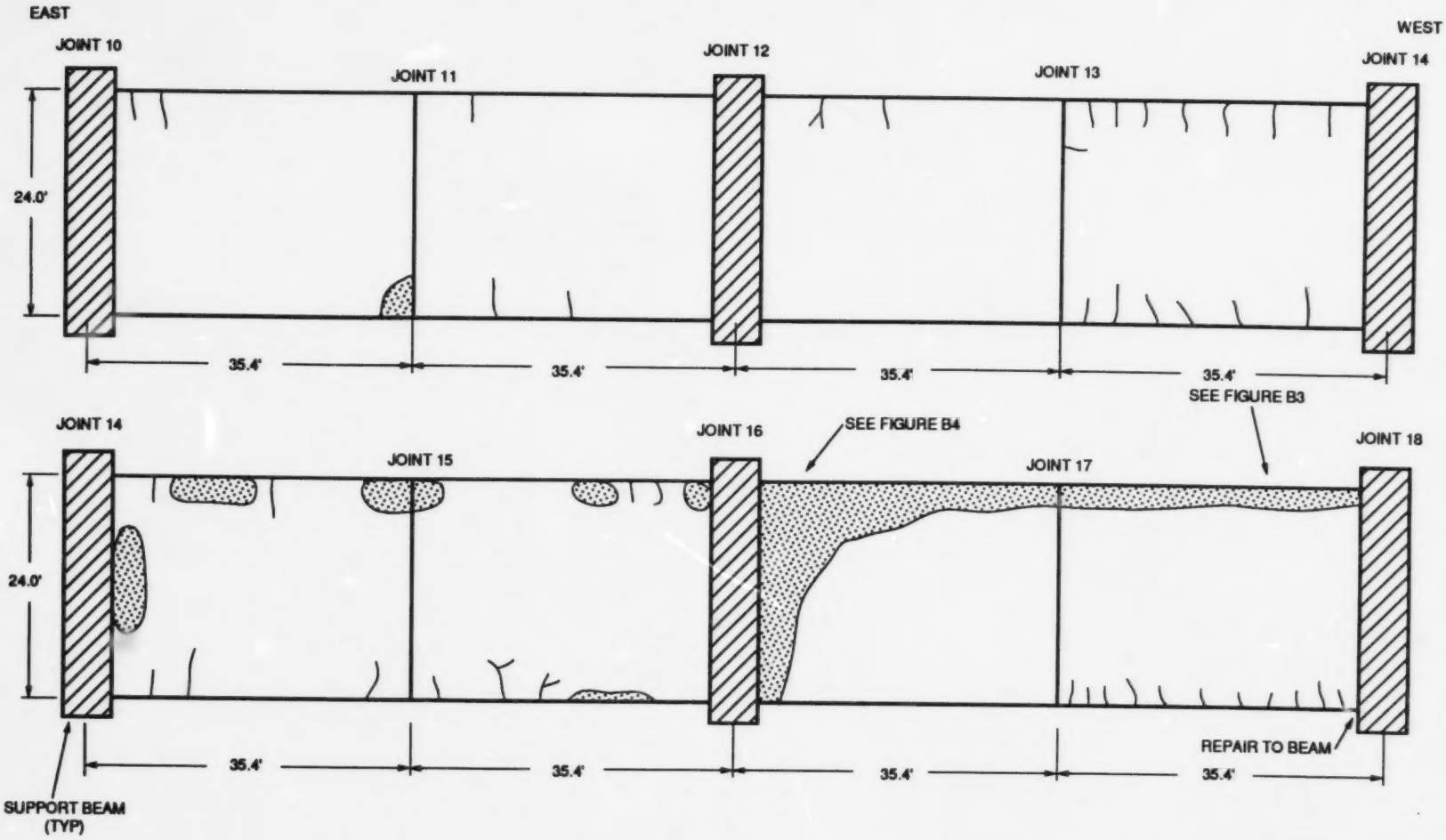


FIGURE B1 CONT'D

PICKERING NGS 'A'
PRESSURE RELIEF DUCT - EXTERIOR CONCRETE
BOTTOM SURFACE

88-295 178833-RD
JA 10 DISK

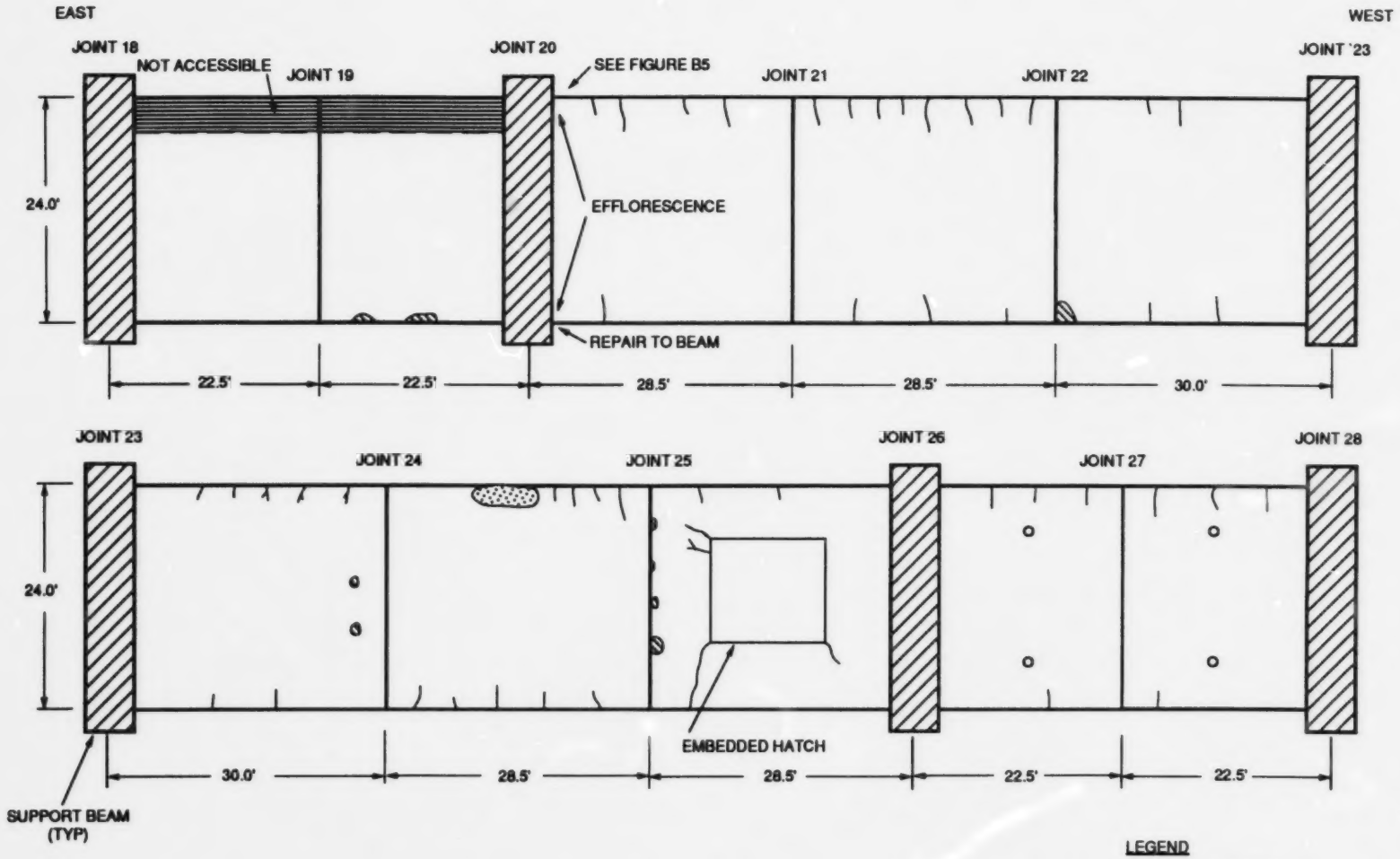


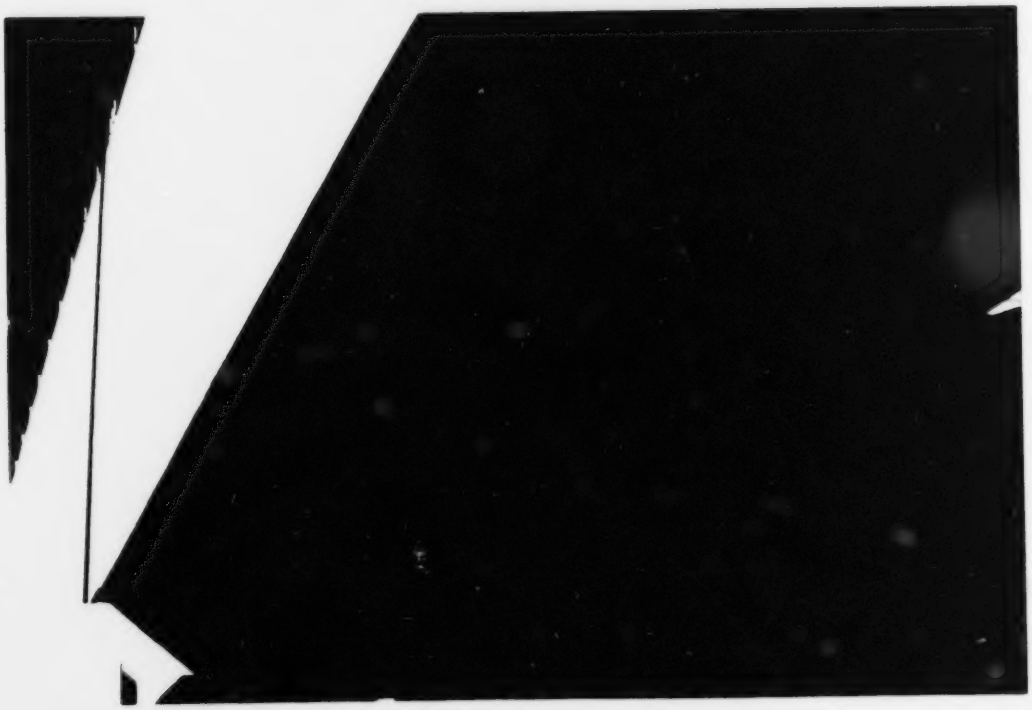
FIGURE B1 CONT'D

PICKERING NGS 'A'
PRESSURE RELIEF DUCT - EXTERIOR CONCRETE
BOTTOM SURFACE

178834-RD
JA 10 DSK

Figure B2 - Cracks in the bottom of the PRD on the south side of the duct between Joints 2 and 5.

Figure B3 - Cracks in the bottom of the south side of the PRD between Joints 17 and 18. Note that the cracks are confined to the edge of the duct.



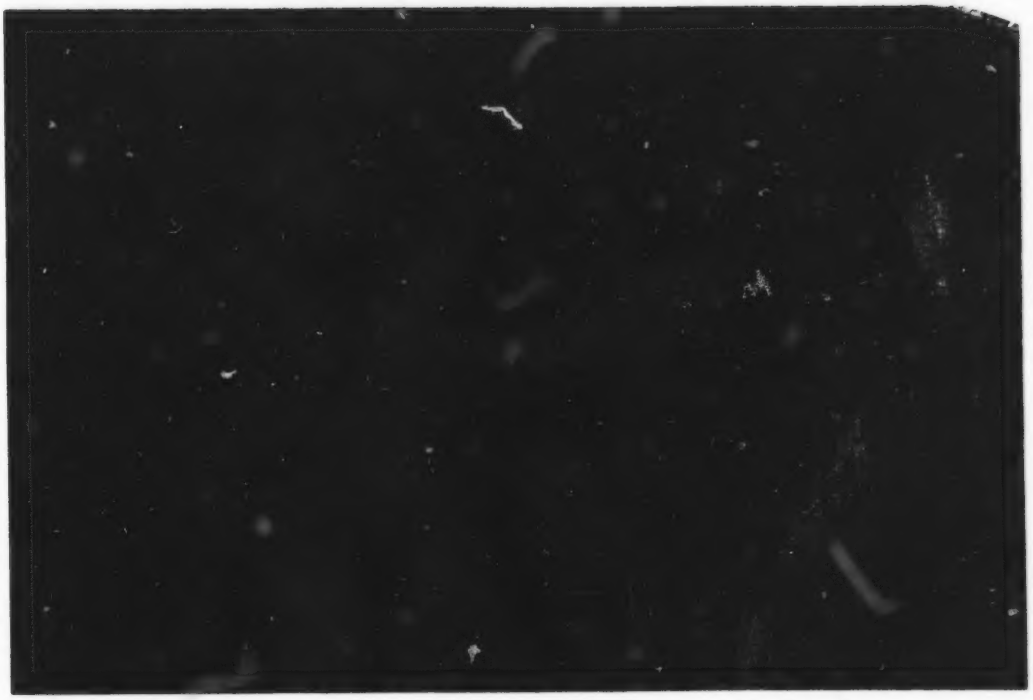


Figure B4 - Map cracking in the bottom of the duct on the west side of Joint 16.

Figure B5 - Repair to the support beam on the west side of Joint 20. Note the cracking and efflorescence.

APPENDIX C

PICKERING NGS 'A'
PRESSURE RELIEF DUCT
NORTH ELEVATION - LOCATION OF CRACKS

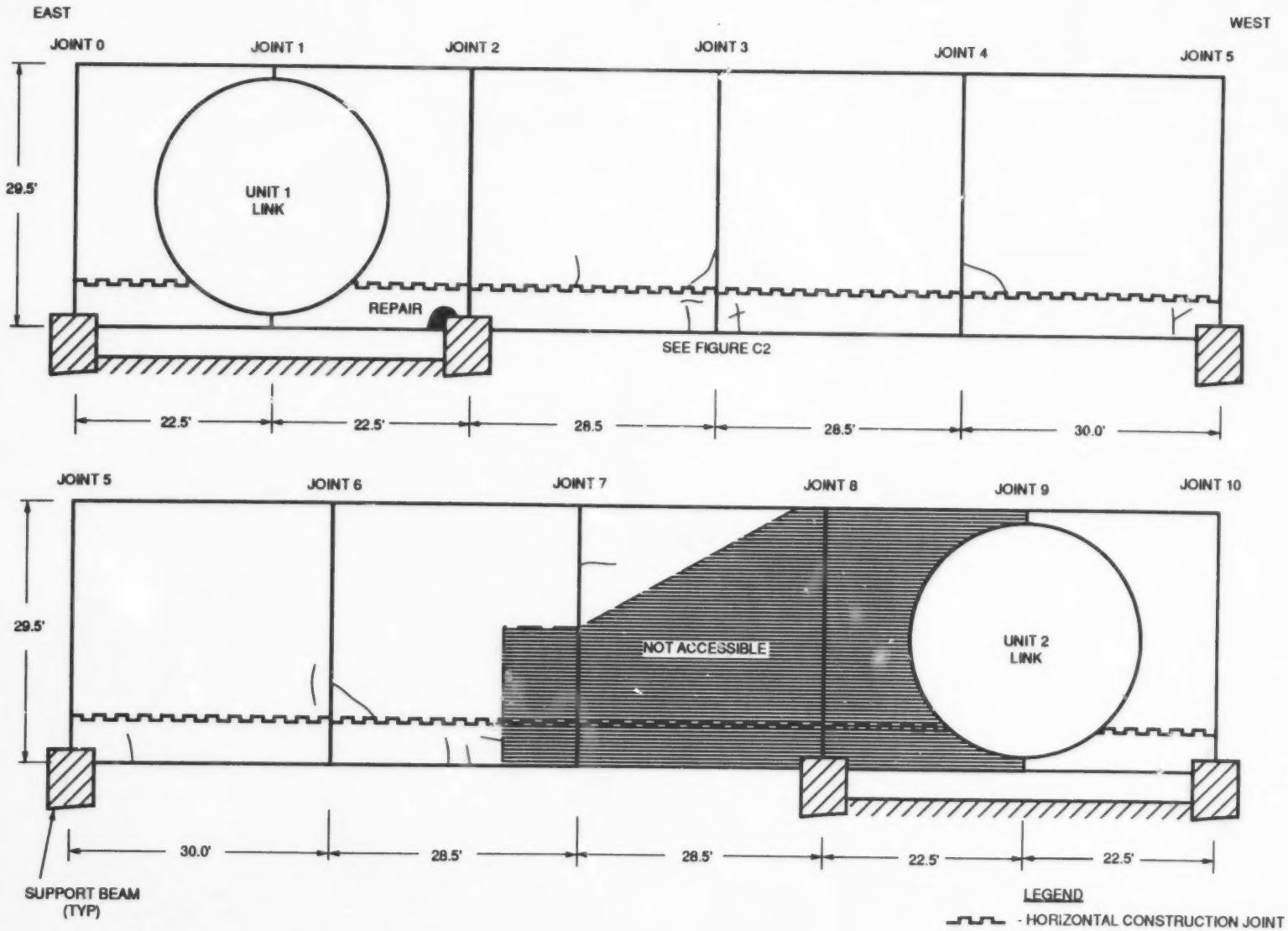


FIGURE C1
PICKERING NGS 'A'
PRESSURE RELIEF DUCT - EXTERIOR CONCRETE
NORTH ELEVATION

178635-RD
JA 10 DISK

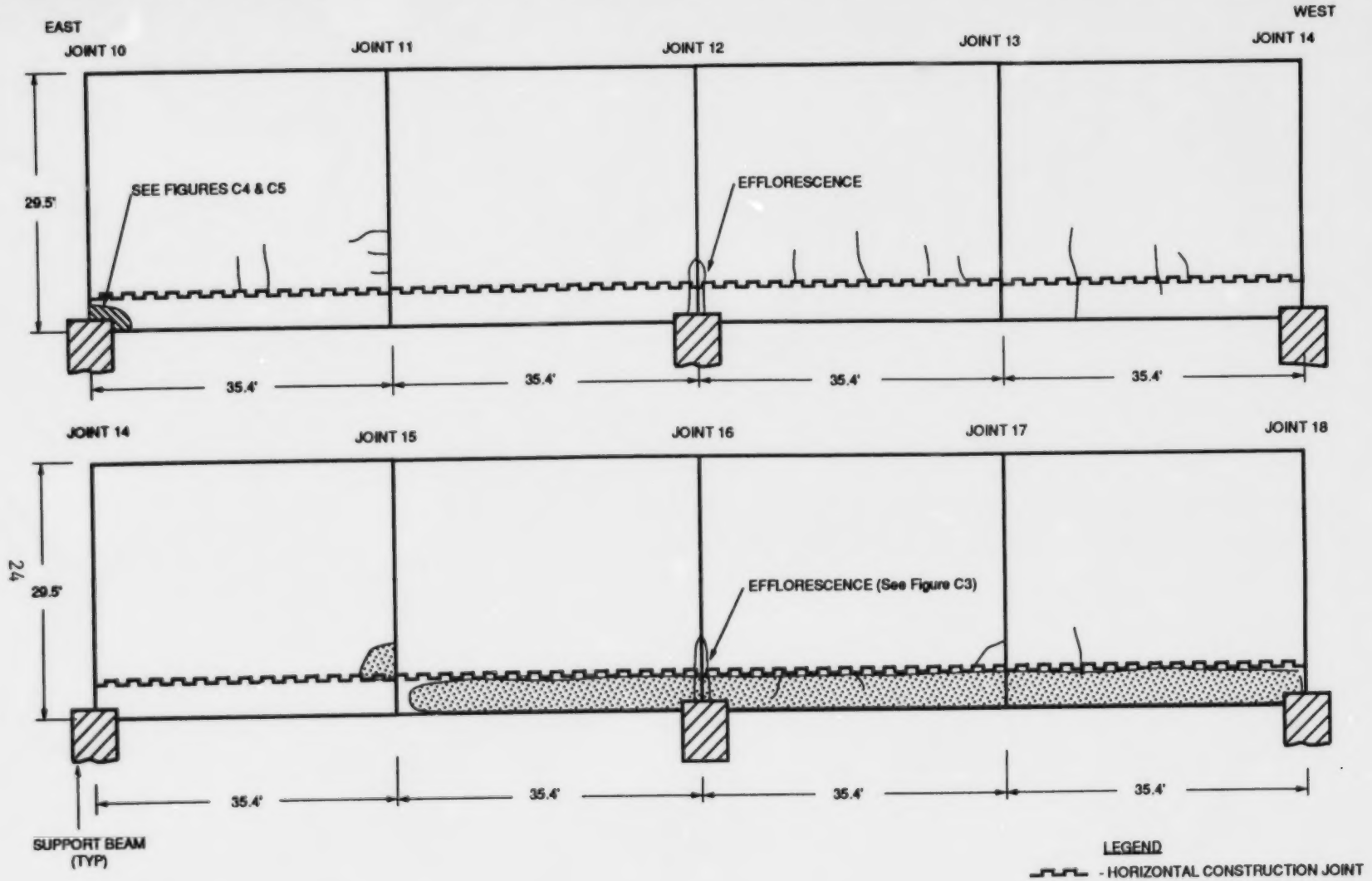


FIGURE C1 CONT'D
PICKERING NGS 'A'
PRESSURE RELIEF DUCT - EXTERIOR CONCRETE
NORTH ELEVATION

88-295

178636-RD
JA 10 DISK

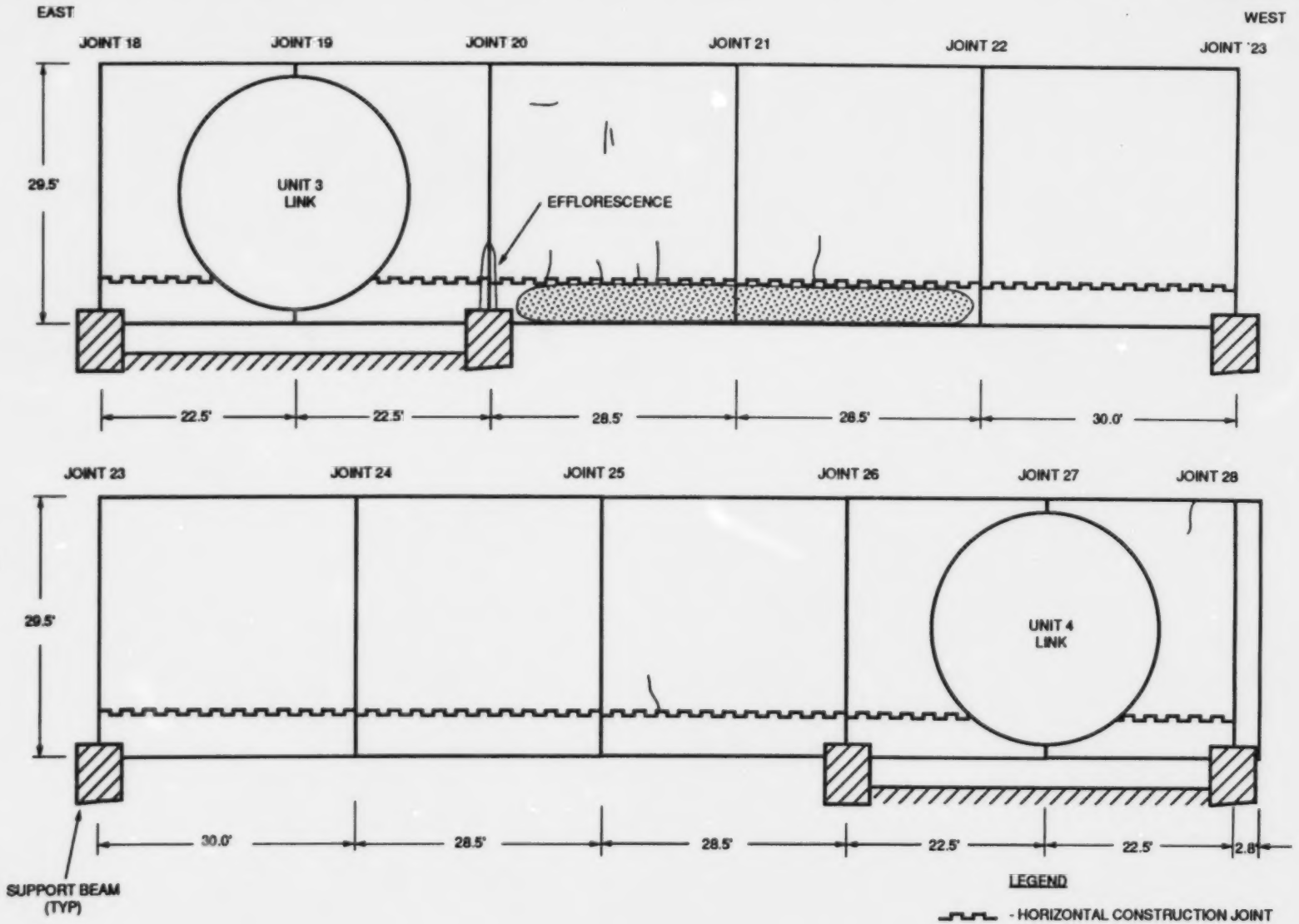


FIGURE C1 CONT'D
PICKERING NGS 'A'
PRESSURE RELIEF DUCT - EXTERIOR CONCRETE
NORTH ELEVATION

88-295

170637-RD
JA 10 01 8K

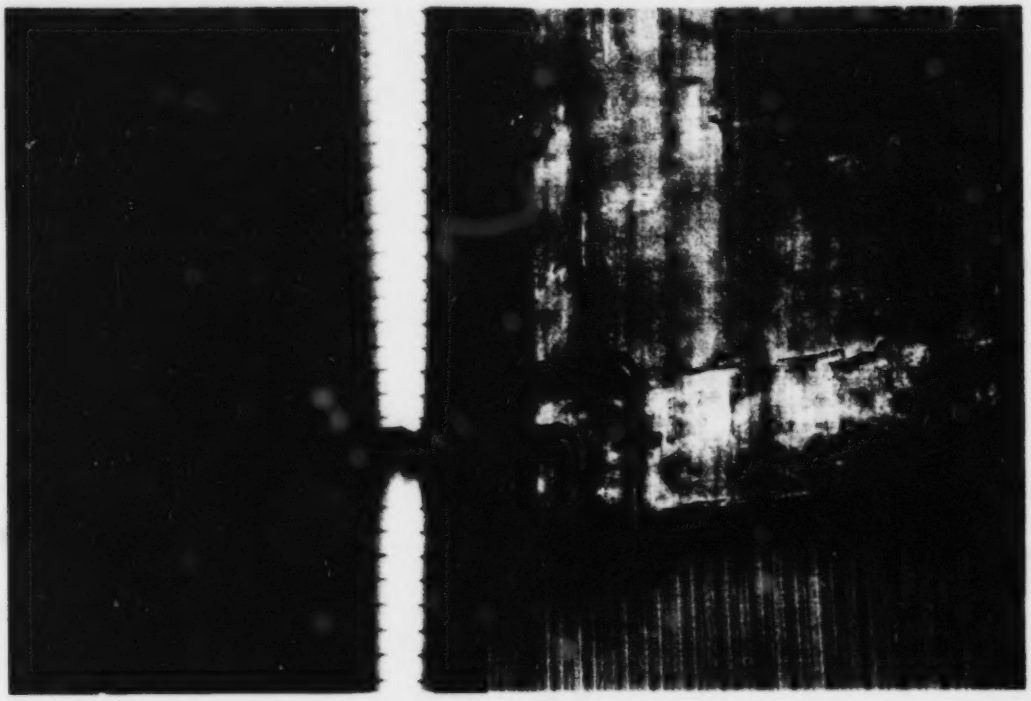


Figure C2 - Cracks in the north side of the duct at Joint 3.

Figure C3 - Efflorescence on the north side of the duct at Joint 16.

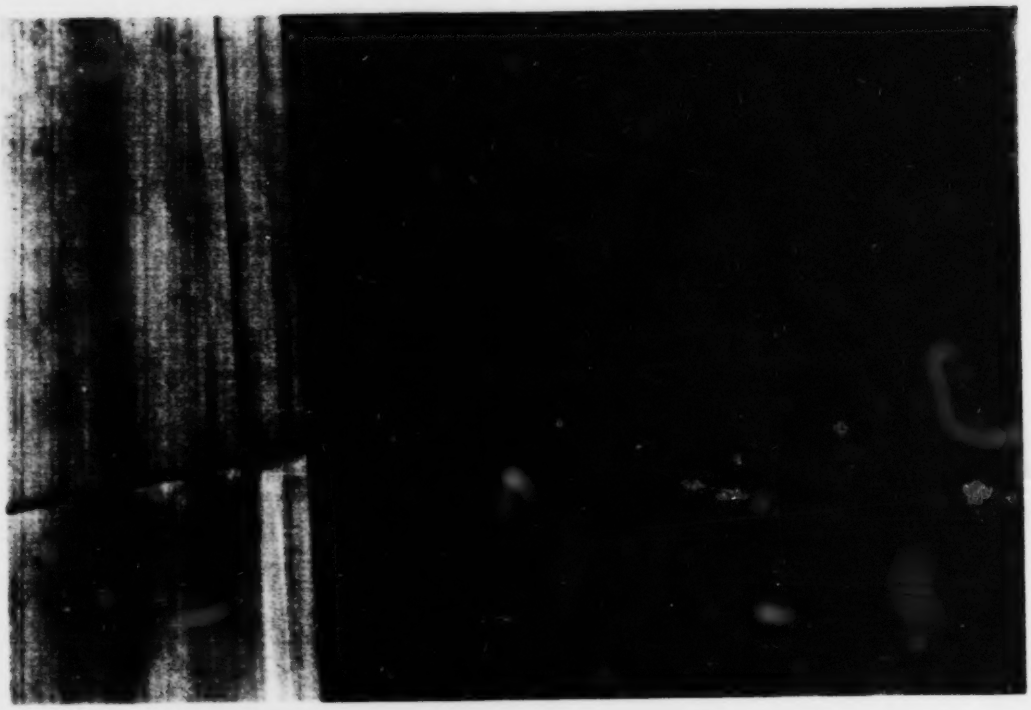


Figure C4 - Spalled concrete above the bearing pad at the west side of Joint 10.

Figure C5 - West side of Joint 10 as viewed from the top of the duct. Note the spalled concrete.

APPENDIX D

PICKERING NGS 'A'
PRESSURE RELIEF DUCT
SOUTH ELEVATION - LOCATION OF CRACKS

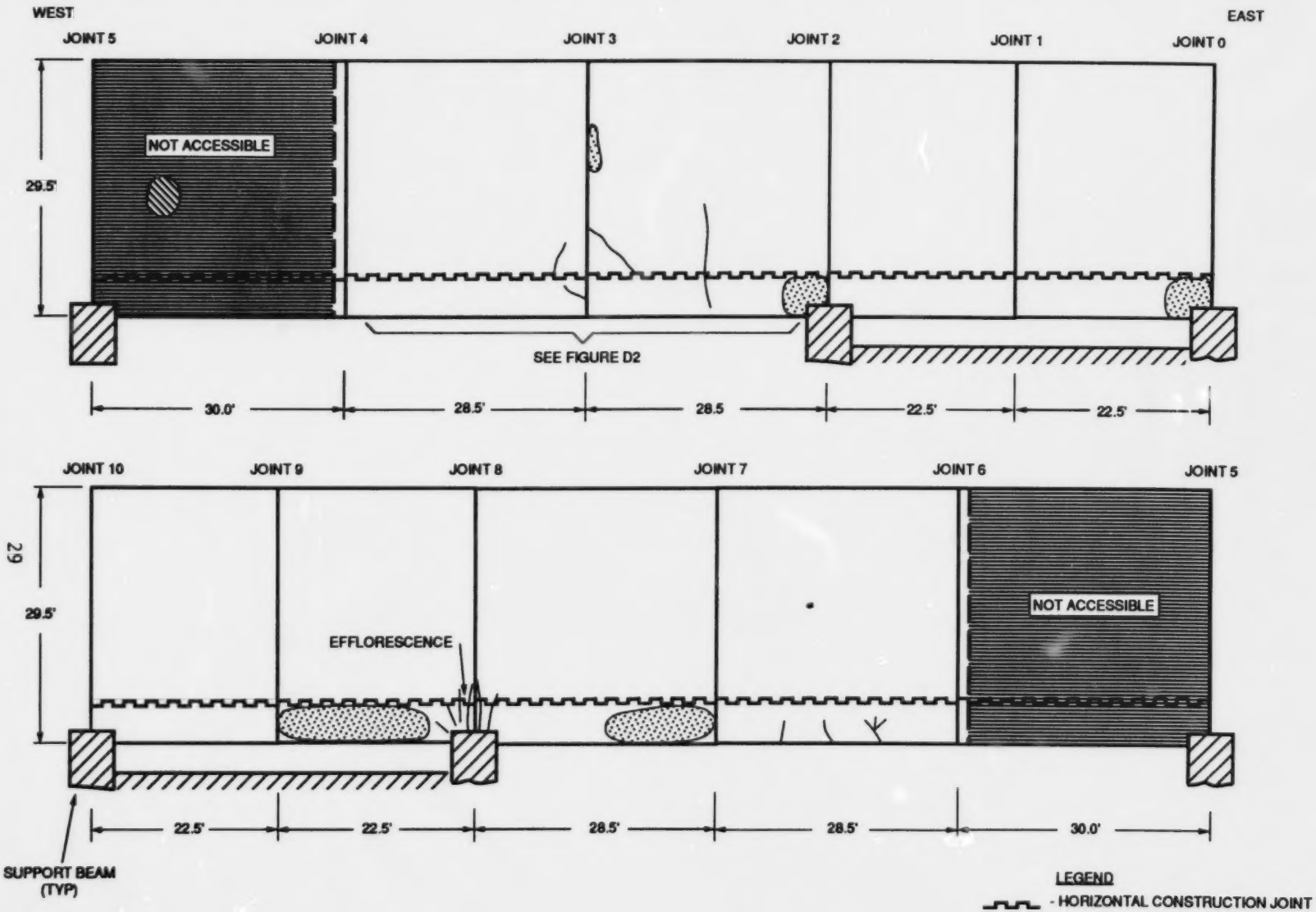


FIGURE D1
PICKERING NGS 'A'
PRESSURE RELIEF DUCT - EXTERIOR CONCRETE
SOUTH ELEVATION

88-295

178830-RD
JA 10 DISK

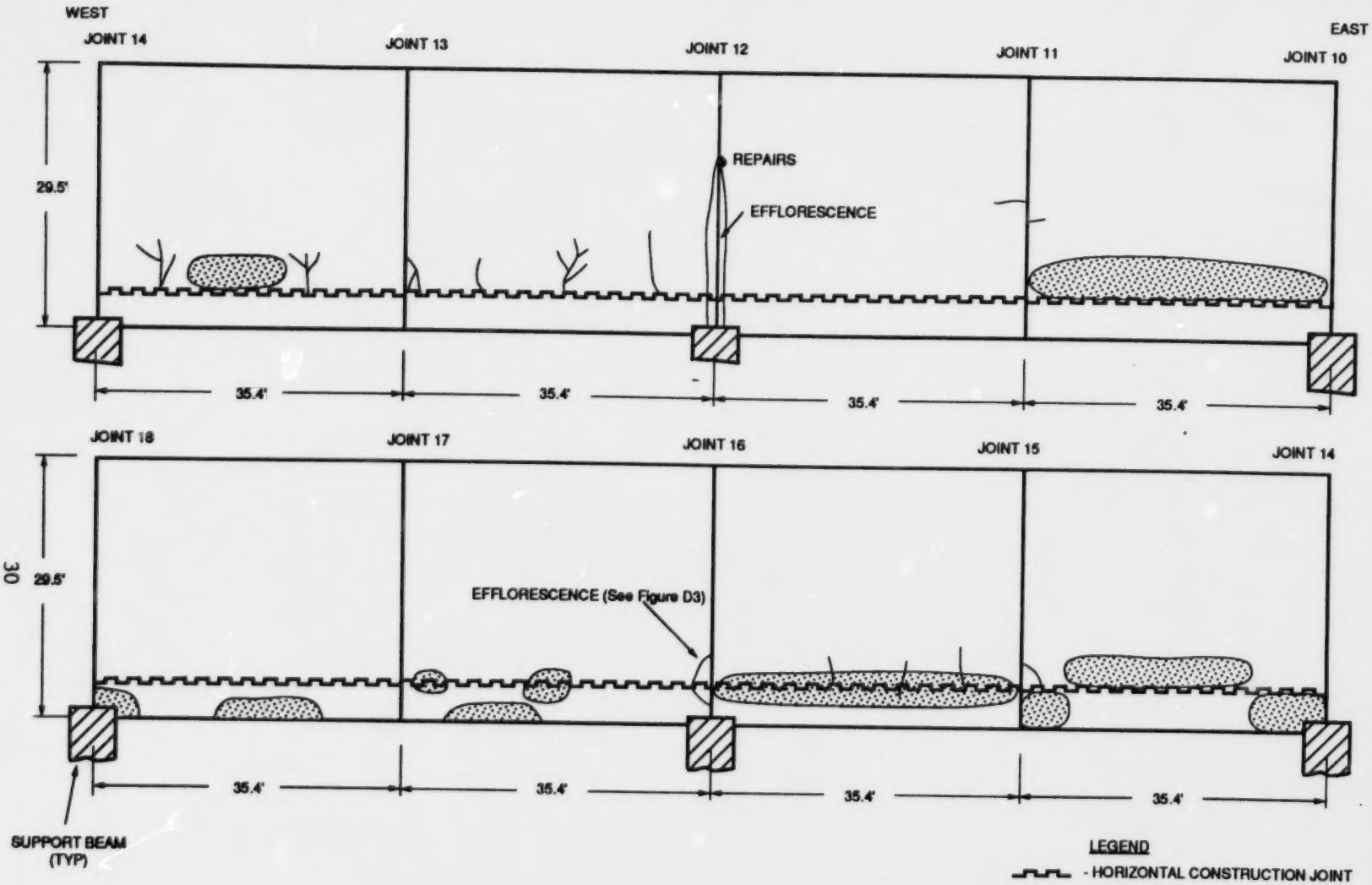


FIGURE D1 CONT'D

PICKERING NGS 'A'
PRESSURE RELIEF DUCT - EXTERIOR CONCRETE
SOUTH ELEVATION

88-295

178639-RD
JA 10 DISK

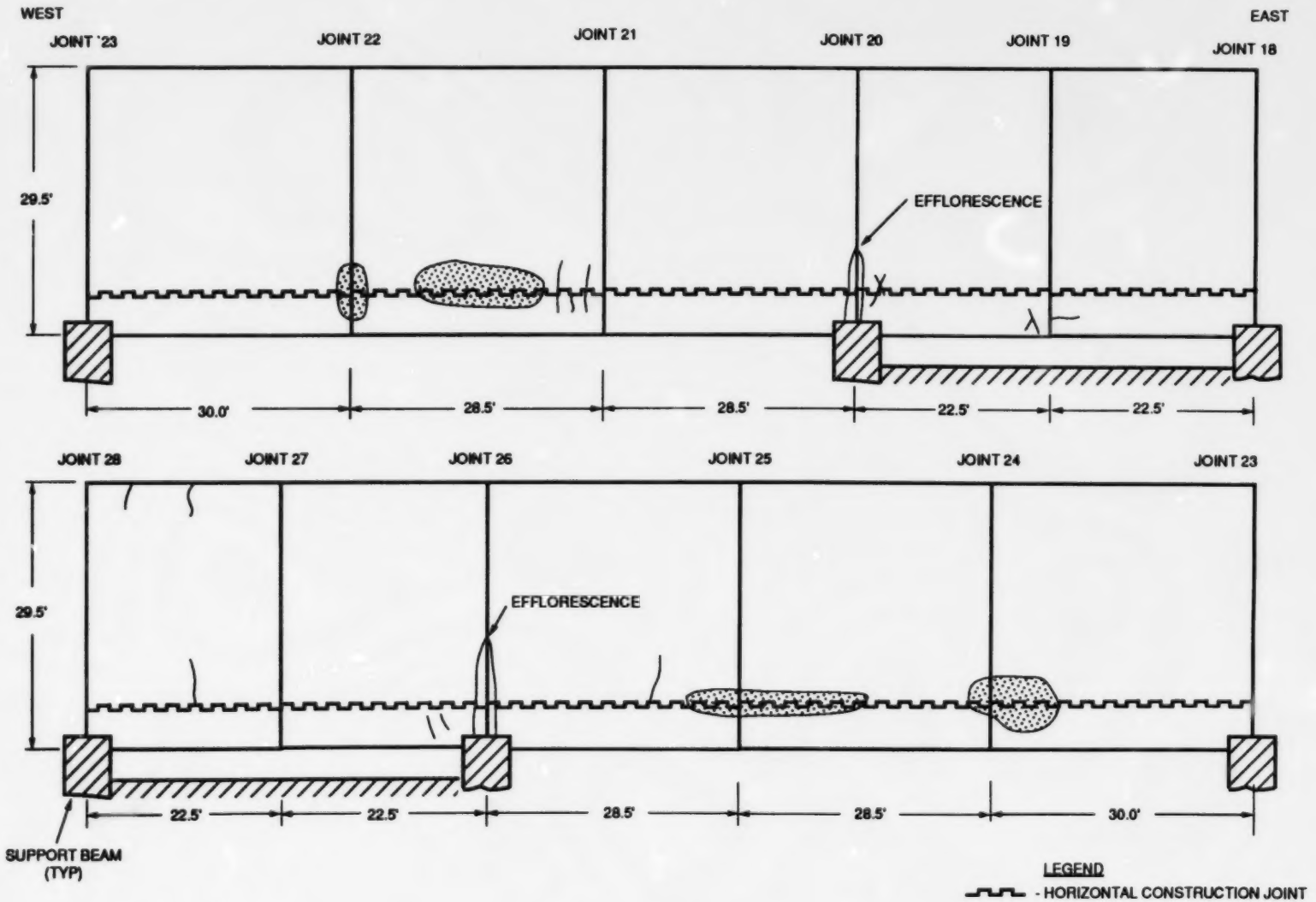


FIGURE D1 CONT'D
PICKERING NGS 'A'
PRESSURE RELIEF DUCT - EXTERIOR CONCRETE
SOUTH ELEVATION

88-295
178640-RD
JA 10 DISK

Figure D2 - Cracks and spall between Joints 2 and 4 on the south side of the duct.

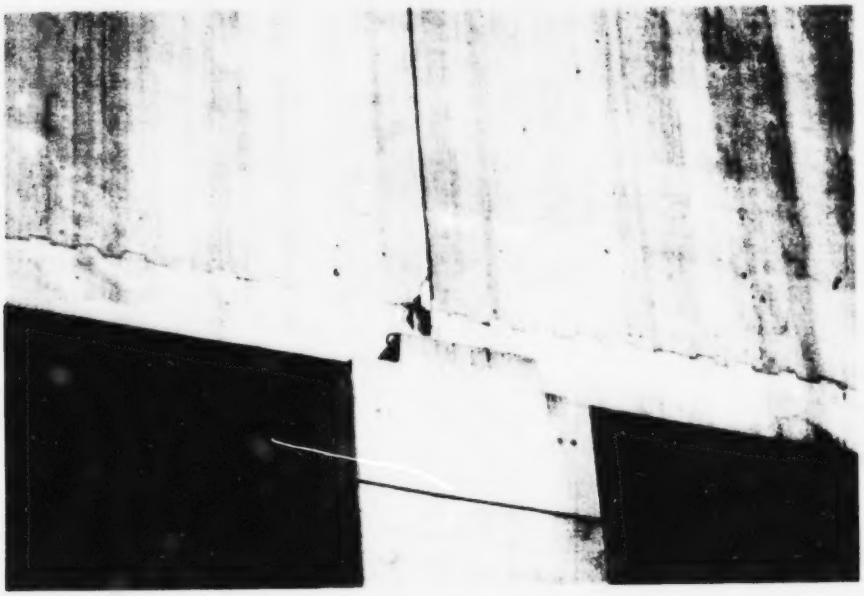


Figure D3 - Crack with efflorescence at Joint 16.